

REMARKS/ARGUMENTS

Claims 7 and 21-23 are pending in the Application. Claim 7 is currently amended. Claims 21-23 are new. Previously presented Claims 1-6 and 8-20 are now canceled without prejudice in favor of divisional prosecution. Canceled Claims 1-6, 8-14, and 16-20 were withdrawn from further consideration by the Examiner as directed to inventions which were non-elected in response to a restriction requirement between multiple groups of claims. In the Office Action dated June 1, 2009 (OA), the Examiner made the restriction requirement final. Applicant hereby confirms the election of Group II, previously presented Claims 7 and 15.

Previously presented Claim 7 is currently amended, previously presented Claim 15 is now canceled, and new Claims 21-23 depend from currently amended Claim 7. Currently amended Claim 7 finds support in the Specification at page 13, first full ¶, which states in pertinent part:

In the present invention, the process of sintering . . . by discharge plasma is a method in which a dried knead-dispersed material is filled between a carbon die and a punch, and direct current pulse is allowed to flow while pressing upper and lower punches

Support for the limits of the temperature range in new Claim 21 and the limits of the pressure range in new Claim 22 is found in Examples 1 to 2 at pages 15-18, and Examples 4 to 8 at pages 20-28 of the Specification. Support for new Claim 23 is found at page 14, first full ¶; Example 3-1 at page 19, first full ¶; and Example 3-2 at page 20, first full ¶, of the Specification.

No new matter is added.

Rejection of Claim 15 under 35 U.S.C. 112, 2nd ¶

Previously presented Claim 15 was rejected under 35 U.S.C. 112, 2nd ¶, as vague and indefinite in the terms “low” and “high” with reference to temperature and pressure. Claim 15 is now canceled. New Claims 21-23 recite temperature and pressure ranges drawn from

the limits therefore in Applicant's various examples of one and two step sintering processes described in the Specification. Accordingly, the rejection is moot with respect to canceled Claim 15 and inapplicable to new Claims 21-23.

Rejection of Claim 7 under 35 U.S.C. 103 over JP'502 in view of JP'648

Previously presented Claim 7 was rejected under 35 U.S.C. 103 over JP'502 (JP 10-168502, published June 23, 1998) in view of JP'648 (JP 2000-128648, published May 9, 2000)(OA, pp. 6-7). As did the Examiner, we refer to the English translations of JP'502 and JP'648 entered of record. The Examiner's rejection should be withdraw with respect to currently amended Claim 7 and new Claims 21-23 dependent thereon.

The object of Applicant's currently claimed method is to produce a carbon nanotube dispersed composite material having as many of the excellent electrical conductivity, heat conductivity, and strength characteristics of long-chain nanotubes as possible along with the properties attributed to the ceramic or metal base materials in the composite material (Spec., p. 5, first full ¶). Prior art methods for dispersing carbon nanotubes in a ceramic or metal base have employed short-chain carbon nanotubes in order to obtain an adequate dispersion of the carbon nanotubes in the composite material (Spec., p. 4, first full ¶). However, while composite materials comprising short-chain carbon nanotubes have adequate heat conductivity, they generally lack the electrical conductivity and strength properties required for use in heat radiation plates and thermal machinery such as heat exchangers. Composite materials excellent only in heat conductivity are not useful as heat radiation plates and heat exchangers. Accordingly, Applicant endeavored to discover how to provide ceramic or metal-based composite materials with the superior heat conductivity, electrical conductivity and strength characteristics of long-chain nanotubes.

Applicant discovered that composite materials having superior electrical conductivity, heat conductivity and strength properties can be produced by the claimed method which

comprises kneading and dispersing a ceramics (but excluding alumina) powder or metal (but excluding aluminum and its alloy) powder and long-chain carbon nanotubes in an amount of 10 wt% or less by a ball mill, and sintering the knead-dispersed material by discharge plasma, in which the knead-dispersed material is filled between punches in a die, and pulse current is allowed to flow through the material while pressing. Applicant's claimed combination of ball mill kneading and dispersing ceramic or metal powder including up to 10 wt% of long-chain nanotubes and sintering the composite by a specific discharge plasma method produces composite materials including long-chain carbon nanotubes which not only have excellent heat conductivity properties but also have the excellent electrical conductivity and excellent strength properties required for use in heat radiation plates and heat exchangers (Spec., pp. 5-7, Disclosure of the Invention).

Applicant states (Spec., pp. 5-6, bridging ¶):

[T]he present inventors . . . found that if long-chain carbon nanotubes . . . are kneaded and dispersed together with calcinable ceramics and metal powder by ball mill, and this is integrated by discharge plasma, then, carbon nanotubes can be dispersed in the form of [a] network in the sintered body, and the above-mentioned object can be attained

In the process of sintering by discharge plasma which Applicant found most effective, "pulse current is allowed to flow while pressing by punches" (Spec., p. 13, first full ¶). By this method, the proportion of impurities inhibiting the heat conductivity, electrical conductivity and strength properties are reduced, and the heat conductivity, electrical conductivity and strength properties of the composites are improved to the levels achieved where a hot press is used. In other words, Applicant's claimed method so uniquely affects impurities on the surface of lon-chain carbon nanotubes that heat conductivity, electrical conductivity and strength properties are simultaneously improved. Improving the electrical conductivity of a ceramic sintered body enables one skilled in the art to discharge work the body with ease. The benefit to the industry is significant.

The Examiner argues that “it would be obvious to a person of ordinary skill to synthesize the carbon nanotube composite material (JP’502) utilizing the discharge plasma (JP’648). The suggestion or motivation for doing so would have been to make a homogeneous compact body that has low defect (JP’648)” (OA, p. 6, last full ¶). However, JP’648 would only have led persons having ordinary skill in the art to make homogeneous compact bodies with minimal defects from granular or powder ceramic and metal materials. The teaching in JP’648 does not support a conclusion that the method Applicant claims for producing a long-chain carbon nanotube dispersed composite material would have been obvious to a person having ordinary skill in the art.

JP’648 describes methods for producing homogeneous compact bodies from granular or powder materials by discharge plasma sintering. JP’648 seeks to reduce surface defects which result when sintering compact granular or powder materials [0002-0008; 0010-0012; 0019-0021]. The granular materials JP’648 contemplates are granular ceramic and/or metal materials with an average particle diameter of 0.1 to 200 micrometers [0019-0021; 0025-0027]. JP’648 teaches [0033]:

[T]he green compact after the obtained pressurization becomes high-density, and, moreover, becomes uniform [the density]. Therefore, in order to contract uniformly while contraction percentage decreases when it sinters by an electric discharge plasma sintering process, the accuracy of dimension of the sintered compact finally obtained becomes uniform [the density of a sintered compact] highly, and generating of sintering defects, such as a crack and a deficit, is controlled.

JP’648 states at [0035], “[B]y what granular material . . . is pressurized beforehand and considered as the green compact before sintering, the sintering nature of electric discharge plasma improves, and it becomes high-density [the density of the obtained sintered compact], and uniform.”

The granular material JP’648 uses as the starting green compact to be sintered is taught to be critical because the method JP’648 describes is designed to produce a “high-density [the density of the obtained sintered compact], and uniform” product [0035]. To

achieve that goal, JP'648 prefers to use granular ceramic oxides or nitrides as the green compact [0048]. It is important to the method JP'648 describes that the green compact material does not decompose easily under high temperature, and it is most important that "such material does not . . . have gasifying or carbonizing" [0049]. Therefore, the green material employed preferably is an oxide of aluminum, titanium and/or zirconium or a nitride of boron, silicon, aluminum and/or titanium [0050-0051]. The presence of carbon materials in the green material does not appear to be desirable. To the contrary, JP'648 teaches away from including carbon in the green granular material to be sintered because a product of uniform high density cannot be produced by discharge plasma sintering such a composite without cracking or deficits. See *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, ____ (2007) ("[W]hen the prior art teaches away from combining certain known elements, discover of a successful means of combining them is more likely to be nonobvious."

On the other hand, JP'502 discloses a method for producing a powder sintered body which may include carbon nanotubes, but sintering is not performed by discharge plasma, the carbon nanotubes contemplated are not long-chain carbon nanotubes, and the reference is concerned only with producing a heat conductive material. JP'502 instructs that the purpose of its invention is to provide "the high-heat-conductivity material which has high heat conductivity, and . . . [a] new high-heat-conductivity material which has still higher hydrophilicity and corrosion resistance so that it can become [an alternative] . . . material [to those] currently used conventionally, such as copper and an aluminum" [0004]. Again, JP'502 is concerned only with producing a sintered composite having high heat conductivity.

JP'502 teaches that crystalline carbon materials, such as natural or synthetic graphite whose heat conductivity is higher than copper, and carbon fiber, can be mixed with metals such as copper to form composites with heat conductivity more than twice as high as copper [0005]. While the carbon content in the mixture may be as low as 10 wt% as shown in

Example 1 [0018], JP'502 teaches composites wherein the metal powder is distributed in a carbon matrix, e.g. at least 30 wt% crystalline carbon material, has especially high heat conductivity [0005] as shown in Examples 1-6 [0019-0023].

The composites of Examples 1-6 in JP'502 all appeared to have been ball-milled and then hot-pressed. The composites so formed exhibit the heat conductivities recorded in Table 1 [0028], reproduced below:

Ex. 1[0018]:	10 wt% natural graphite	90 wt% copper powder	526 W/mK
Ex. 2[0019]:	30 wt% natural graphite	70 wt% copper powder	799 W/mK
Ex. 3[0020]:	50 wt% natural graphite	50 wt% copper powder	963 W/mK
Ex. 4[0021]:	30 wt% natural graphite	70 wt% aluminum dust	493 W/mK
Ex. 5[0022]:	30 wt% natural graphite	70 wt% iron powder	149 W/mK
Ex. 6[0023]:	30 wt% artificial graphite	70 wt% nickel powder	173 W/mK

The Examiner will recognize that the ball-milled/hot pressed composites exemplified in JP'502 all employ graphite carbon. Moreover, the Examiner will also recognize that the heat conductivity of the exemplified composites improves significantly as the graphite content in the composite is increased from 10 to 30 wt% and improves more significantly as the graphite is increased from 10 to 50 wt%. Persons having ordinary skill in the art would have taken particular notice that: (1) composites having a crystalline carbon content of 10 wt% or less are inferior to composites having a higher crystalline carbon content [0005; Table 1, Examples 1-3], (2) the exemplified composites were all sintered by hot pressing methods [0015-0016], (3) none of the examples employs carbon nanotubes as the crystalline carbon material, and (4) JP'502 does not mention long-chain carbon nanotubes or distinguish long-chain carbon nanotubes from other carbon nanotubes.

First, carbon nanotubes would not be used to form a carbon matrix for the composites JP'502 describes if graphite imparts substantially the same or better heat conductivity.

Graphite is a far less expensive crystalline carbon form. *KSR, supra*, instructs that economic concerns should be taken into account when determining obviousness. JP'502 teaches that "[c]omposite[s] with higher heat conductivity can be obtained by using good crystalline carbon materials, for example, natural graphite, artificial synthetic graphite, etc." [0010].

Second, Applicant is not surprised that JP'502 does not mention the electrical conductivity of composites formed from metal powder and crystalline carbon material. JP'502 teaches that any kind of crystalline carbon material may be effectively used to improve the heat conductivity of the composite [0010]:

As crystalline carbon materials, natural graphite, artificial synthetic graphite, carbon fiber, fullerene, a carbon nanotube, and carbon materials that have other crystallinity can be used. Crystalline carbon materials can use it as powder or a stable fiber. . . .

On the other hand, Applicant's Specification (Spec., p. 4, ¶2) cites prior art which shows a clear preference in the art for using carbon nanotubes having a length as short as possible when dispersing carbon nanotubes in resin-based compositions and aluminum alloys because short-chain carbon nanotubes have superior dispersability and skilled artisans showed little or no interest in any other properties other than heat conductivity for the composites. Unlike Applicant's disclosure, the prior art cited in Applicant's Specification and the prior art the Examiner applied against the claims show no concern whatsoever for any property other than heat conductivity. And, where heat conductivity is the primary concern, the prior art reasonably suggests that persons having ordinary skill in the art would prefer graphite to all other forms of crystalline carbon materials and prefer short-chain carbon nanotubes to any other length of nanotubes for its dispersability in resin, metal or ceramic-based composites.

The Examiner has not explained why persons having ordinary skill in the art reasonably would have been led by the combined teachings of JP'648 and JP'502 to knead and disperse long-chain nanotubes in metal or ceramic powders by ball milling and sinter the composites by discharge plasma in which the knead-dispersed material is filled between

punches in a die, and pulse current is allowed to flow while pressing, when JP'648 would have taught persons having ordinary skill in the art to avoid carbonizing the composite, when JP'648 would have taught persons having ordinary skill in the art to sinter by hot pressing, when JP'502 would have taught persons having ordinary skill in the art to use any type of crystalline carbon to improve heat conductivity and prefers natural or synthetic graphite, when JP'502 would have taught persons having ordinary skill in the art to use crystalline carbon/metal composites wherein the crystalline carbon is the matrix, i.e., crystalline carbon is present in an amount greater than 30 wt%, when the prior art as a whole would have taught persons having ordinary skill in the art to use short-chain carbon nanotubes in resinous and ceramic compositions because its dispersibility therein is superior to that of long-chain carbon nanotubes, and when persons having ordinary skill in the art were only concerned with heat conductivity. Unlike other persons skilled in the art, Applicant is concerned not only with heat conductivity, but also with electrical conductivity and strength properties. Applicant alone endeavored to find a process for imparting the combined superior heat conductivity, electrical conductivity and strength properties of long-chain carbon nanotubes to ceramic or metal-based composites without cracking, cavities, or other detrimental effects. To achieve that goal, Applicant had to solve and/or eliminate the dispersibility and sintering problems which the prior art associated with long-chain carbon nanotubes.


Persons having ordinary skill in the art would not have been led by the teachings of JP'502 and JP'648 to do what Applicant has done without very good reasons to do so. However, even if one finds some motivation in the prior art to try to sinter a mixture of a crystalline carbon in a ceramic or metal material, given the wealth of teachings in the prior art not to do, persons having ordinary skill in the art would not have had the reasonable expectation of success required to sustain a conclusion of obviousness. *In re O'Farrell*, 853 F.2d 894, 903 (Fed. Cir. 1988).

The applied prior art does not reasonably suggest the results achieved by Applicant's unique method of producing a carbon nanotube dispersed composite material comprising: (1) kneading and dispersing a ceramics (but excluding alumina) powder or metal (but excluding aluminum and its alloy) powder and long-chain carbon nanotubes in an amount of 10 wt% or less by a ball mill; and (2) sintering the knead-dispersed material by discharge plasma, in which the knead-dispersed material is filled between punches in a die, and pulse current is allowed to flow while pressing, i.e., the improved combination of heat conductivity, electrical conductivity, and strength properties. The greater weight of the evidence of record favors patentability. Whatever motivation the art provides to try to sinter the composites of JP'502 comprising metal powder in a crystalline carbon matrix by the discharge plasma method described in JP'648 as suitable for sintering granular materials free of detrimental carbon is far outweighed by the suggestions not to do so in the same references and the prior art as a whole. Accordingly, the Examiner's rejections for obviousness should be withdrawn.

For the reasons stated herein, Applicant's claims are patentable over the applied prior art and otherwise in condition for allowance. Early notice of allowance is respectfully requested.

Respectfully submitted,

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